AR-008-567 (1)

DSTO-TR-0029

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DEPARTMENT OF DEFENCE
DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

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DSTO Technical Report
DSTO-TR-0029

Abstract

Electrostatic sensitivity tests were conducted on M52A3B1 primers using an electrostatic discharge (ESD) gun to simulate human static discharge. The data were analysed by the Bruceton, probit, logit and AMCR techniques. The no-fire threshold (NFT) for electrostatic discharge was determined.

DEPARTMENT OF DEFENCE
DSTO AERONAUTICAL AND MARITIME RESEARCH LABORATORY

Published by

DSTO Aeronautical and Maritime Research Laboratory
GPO Box 4331
Melbourne Victoria 3001 Australia

Telephone: (03) 626 8111
Fax: (03) 626 8999

AR No. 008-567

APPROVED FOR PUBLIC RELEASE

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Electrostatic Testing Of M52A3B1 Primers

1. *Introduction*

There is considerable concern within the Australian Defence Force (ADF) regarding the inadvertent initiation of electroexplosive devices (EED's). To address the specific problem of electrostatic initiation, MRL has commenced a task the aim of which is to recommend a structured electrostatic discharge protection policy. One of the milestones for this task requires the correlation of the DC and electrostatic sensitivities of EED's.

The DC sensitivity of an EED is the more readily available parameter [1, 2]. Until recently there was no suitable method available for testing EED vulnerability to human static discharge. The US uses the 25 kV test [3] for assessing electrostatic sensitivity but this test does not give an indication of the 0.1% function level or of the no-fire threshold, nor does the test circuitry accurately reproduce worst-case human discharge. We have adequately reproduced human static discharge by using a commercially available electrostatic simulator (the KeyTek ESD-1).

Here we will describe the results of sensitivity tests which were conducted on M52A3B1 conducting composition primers. These primers are used in 20 mm ammunition. Australian weapon systems employing this ammunition are the Phalanx Close-In Weapon System (CIWS) as well as the F111C and F/A-18A aircraft cannon. The purpose of these tests was to determine the electrostatic no-fire threshold voltage and energy for the primer. It would then be possible to compare the electrostatic NFT energy with the NFT energy for DC discharge.

2. *Experimental*

2.1 *Materials*

The M52A3B1 primers were provided by the Royal Australian Navy. The primers provided had been filled into cartridge cases - see Figure 1. The projectiles and propellant had been removed from the cartridge cases. The M52A3B1 primer contains a combined priming and conducting mix which is based on lead styphnate and acetylene black.

Figure 1: M52A3B1 primer and associated cartridge case. (Inert primer and bored case).

2.2 *Apparatus*

2.2.1 *ESD Simulator and Accessories*

A KeyTek ESD-1 simulator was used in conjunction with a DN-10 discharge network, a HT-10 hand adapter and a DT-4 tool tip (Figure 2). Ground return to the ESD-1 was provided by a GCL-1 lead. The HT-10, DT-4 and DN-10 combination realistically simulates human static discharge via a hand-held metal tool. This combination of hand and metal tool is widely considered to be a worst-case situation [4]. The ESD-1 was powered by a KeyTek PSC-1 supply (the base of

the ESD-1 in Figure 2). The DN-10 possesses a capacitance of 150 pF and a resistance of 330 Ω.

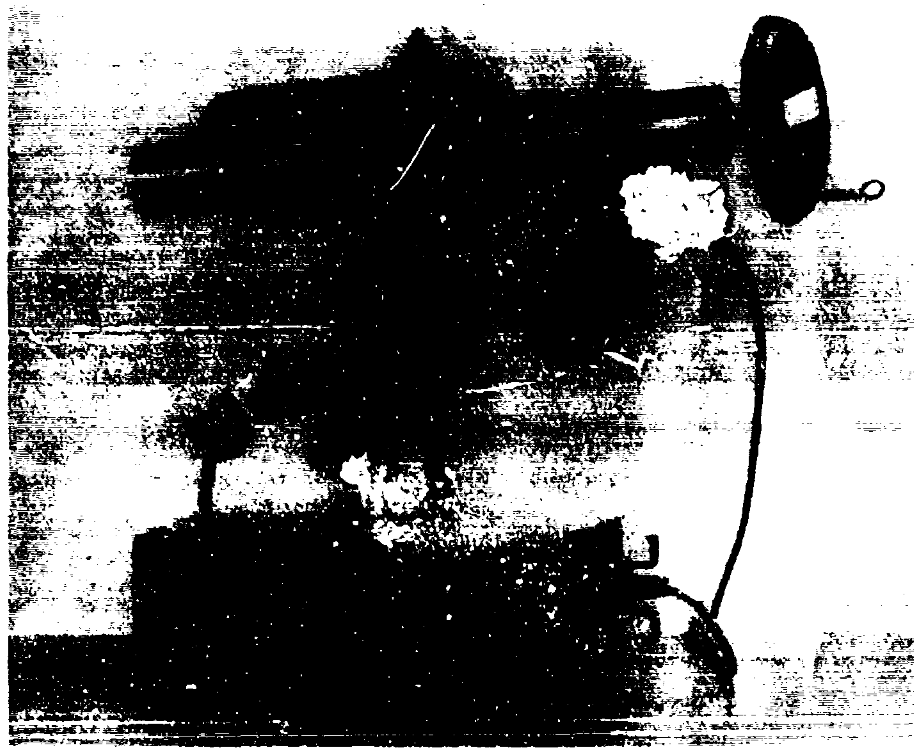


Figure 2: KeyTek ESD-1 electrostatic discharge simulator.

2.2.2 Mechanical Apparatus

The primer and cartridge case were contained in a breech assembly as indicated in Figure 3. The breech assembly was mounted on the motorised turntable as is depicted in Figure 4. The electrode making electrical contact with the primer pole piece (Figure 5) was gold-plated to prevent corrosion during discharge. This gold-plated electrode made contact with the pole piece via a cross-cut spring probe and receptacle. The probe and receptacle were from RS components and could be replaced if they suffered damage from the explosion of the primer. The turntable 'start' position was 55 mm from the 'stop' position, as measured on the turntable periphery. When the turntable reached the 'stop' position, a microswitch was activated to stop the turntable drive motor. The approach speed of the electrode to the DT-4 tip could be varied by changing the voltage setting of the power supply. The same voltage setting of 10 V was used and at this setting the approach speed was found to lie in the range 2.8 mm/s to 2.9 mm/s. The test configuration is depicted in Figure 6.

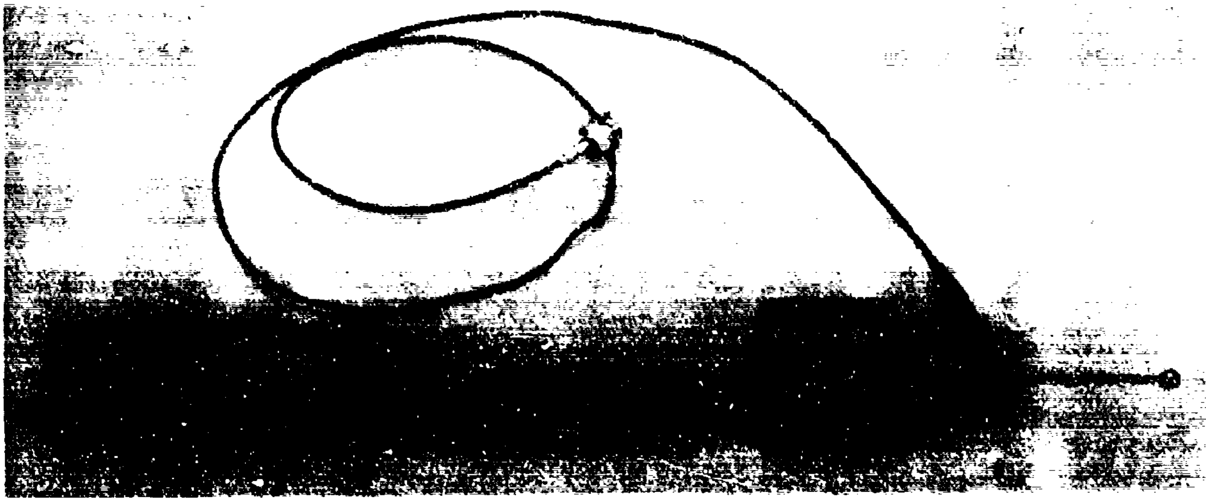


Figure 3: Exploded view of breech assembly and CT-2 current transformer.

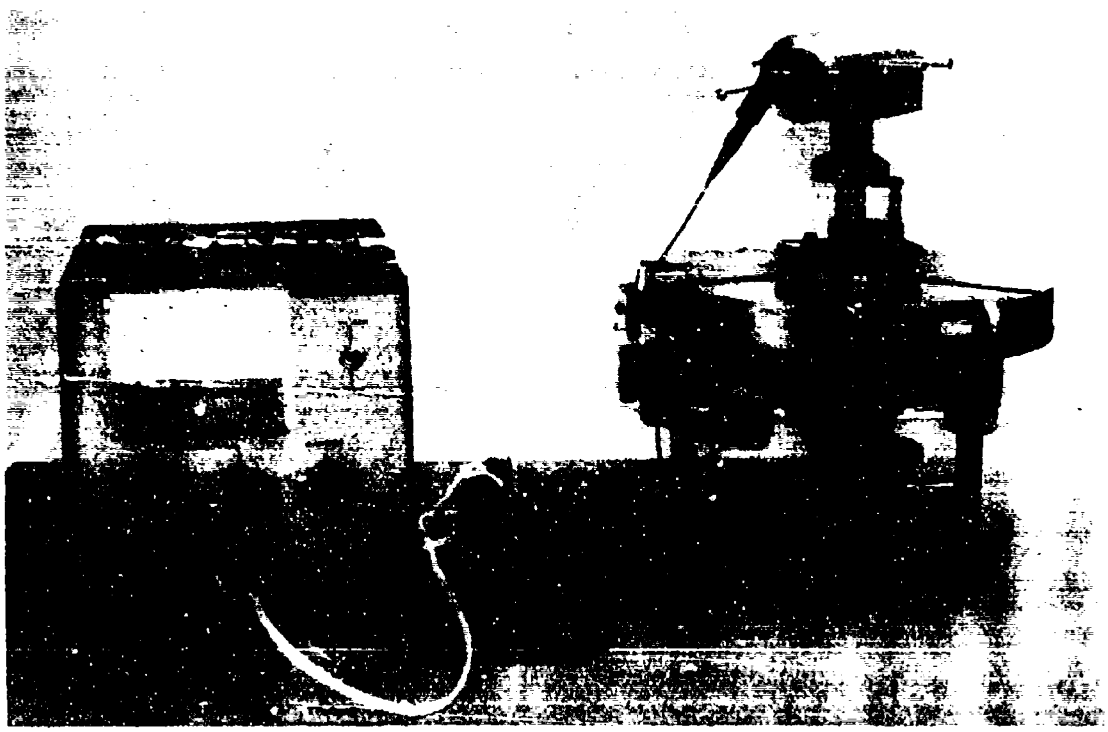


Figure 4: Motorised turntable, switch and associated power supply.

Figure 5: *Close up view of DT-4 tip and gold-plated electrode.*

Figure 6: *Overall view of ESD-1 simulator and turntable*

2.2.3 *Electronics*

The discharge pulse through the gold-plated electrode was monitored by a Tektronix CT-2 current transformer which has a pulse risetime of about 0.5 ns and an insertion impedance of about 0.04 Ω shunted by 5 μH. The output from the CT-2 was relayed to a Tektronix TEK 7844 oscilloscope (Figure 7) via a Tektronix No. 011-0059-02 attenuator, rated at 50 Ω and 2 W. This attenuator reduced the output voltage of the CT-2 by a factor of ten.

The TEK 7844 oscilloscope utilised the 7A19 vertical amplifier. The vertical bandwidth for this amplifier-oscilloscope combination is 400 MHz with a risetime of 0.9 ns. The oscilloscope trace was captured by a Tektronix C-51 camera using Polaroid 667 ASA 3000 film. A Tektronix writing speed enhancer (WSEN) was also used to pre-fog the film before discharge.

The entire discharge assembly was enclosed by a safety cabinet with polycarbonate doors (Figure 8). The firing cabinet was lined with earthed aluminium foil to prevent inadvertent electromagnetic pickup of the spark discharge by the oscilloscope. The firing cabinet was linked to an electrically operated exhaust system (Figure 9).

Figure 7: TEK 7844 oscilloscope and C-51 camera.

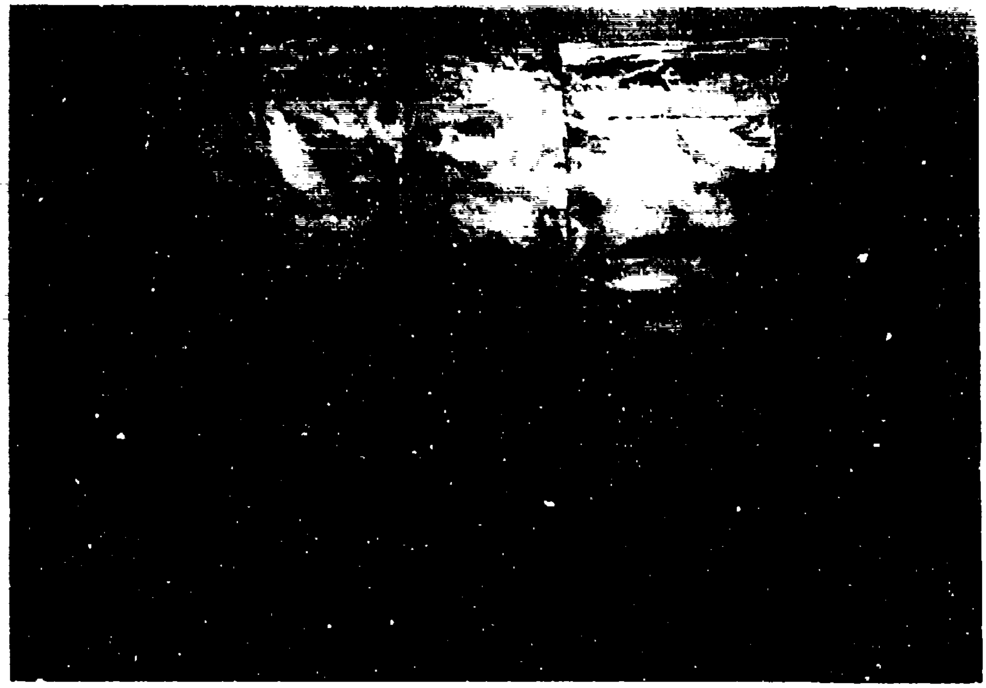


Figure 8: Safety firing box with foil shielding.

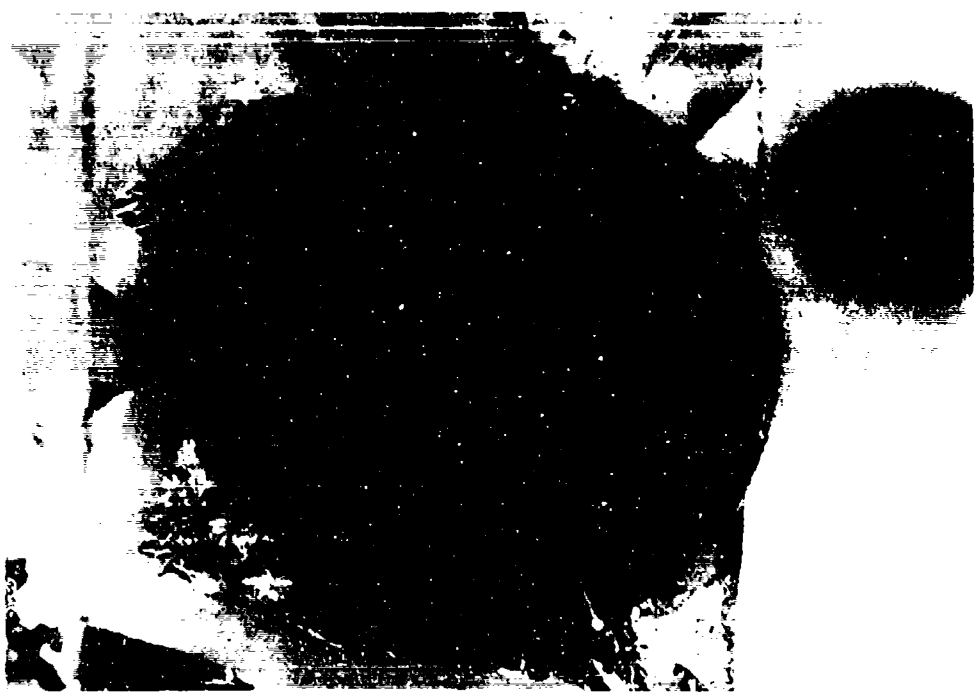


Figure 9: Close up of exhaust vent in the firing box.

2.2.4 *Resistance Measurements*

Primer resistances were measured prior to the ESD tests by means of a Valhalla Scientific 4314AN Digital igniter Tester. Measurements were conducted behind a safety screen.

2.3 *Firing Procedure*

An initial measurement was made of the primer resistance before the cartridge case was inserted into the breech block (see section 2.2.4). After the cartridge case was inserted into the breech block a second resistance measurement was made between the outer surface of the breech block and the gold-plated electrode. This second measurement was performed to test for electrical continuity.

Upon activation, the turntable brought the gold-plated electrode to a distance of 1 mm from the DT-4 discharge electrode. System alignment was checked at this point. The turntable was returned to the starting position. The ESD-1 was energised and the firing box shut. The turntable was then activated again and it moved the gold-plated electrode to the discharge position. The discharge gap increased with increasing discharge voltage.

All the firings were conducted within the firing cabinet. In the event of a 'no-fire' the primer was disposed of by firing at an elevated voltage. This voltage was generally 15 kV. The exhaust system was used to thoroughly clear the firing cabinet of fumes after each firing.

2.4 *Bruceton [5] Procedure*

Primers were fired at 2 kilovolt intervals. An estimate was first made of the 50% function level. A primer was then subjected to this voltage. If the primer fired then further primers were tested at successively lower voltages until a 'no-fire' occurred. If a 'no-fire' occurred primers were tested at successively higher voltages until a 'fire' was recorded. This procedure was repeated in an 'up-down' fashion for 20 shots.

2.5 *Rundown Procedure*

The rundown test consisted of firing separate lots of primers at pre-assigned voltages. The voltage interval was estimated from the Bruceton results. A record was made of the number of 'fires' as well as 'no-fires' which occurred in each lot. This information was then used to estimate distribution parameters. The data were assessed either by the probit [5,6] method, the AMCR [7] method, or by the logit method [6]. The logit method is similar to the probit method but uses a logistic function instead of a normal distribution function.

3. Results and Discussion

3.1 Bruceton Procedure

The results of the Bruceton firings are listed in Table 1. Statistical analysis was conducted by means of a program written by one of the authors [8]. The analysis indicated that the 50 % function level was 3.8 kV. The log mean and standard deviation were 3.5581 and 0.1410, respectively. The Bruceton procedure had been conducted in terms of constant voltage increments. The Bruceton analysis was conducted on the assumption that the voltage sensitivities were log-normally distributed.

3.2 Rundown Procedure

The firing data from the rundown procedure are tabulated in Tables 2 to 10. These data were analysed by using software packages written at MRL [9,10]. As indicated in Table 5 and Table 6, additional firings were conducted at a voltage of 4.2 kV. These additional firings improved the probit and logit fits.

3.2.1 Probit Analysis

A probit analysis of the results was undertaken by means of the software in [9]. The logarithm of the voltage was used as the random variable. Figure 10 is a plot of the logarithms of the voltages against the empirical probits for this analysis. A straight line fit to the data is possible. The results of the analysis may be found in Table 11. The important results are that the 0.1 % function level and no-fire threshold estimates are 1142 V and 799 V, respectively. By assuming that all the energy stored in the discharge network's capacitor is released into the primer, it is possible to estimate the 0.1% FL and NFT energies as 98 μJ and 48 μJ respectively

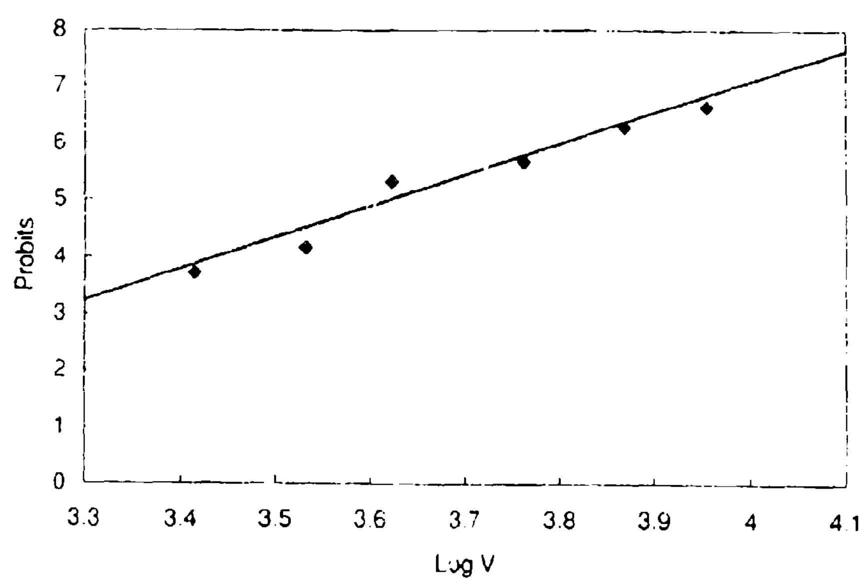


Figure 10: Plot of log voltages against empirical probits. The straight line is the probit regression line.

3.2.2 *AMCR Analysis*

The AMCR analysis was conducted by means of the software developed in [9]. The AMCR analysis indicated a mean of 6.04 kV with a standard deviation of 2.041 kV. If these values are taken as approximations to the population mean and standard deviation then the 0.1% function level is -0.27 kV. This result is clearly physically impossible.

3.2.3 *Logit Analysis*

A logit analysis of the results was conducted using software written by one of the authors [10]. The logarithm of the voltage was used as the random variable. A plot of logarithmic voltage against empirical logit is displayed in Figure 11. The 0.1% function level estimate was 781 V. Assuming that the 0.1% FL is normally distributed, the NFT was calculated as 477 V (95% single-sided confidence interval). The 0.1% FL and NFT energies were therefore 46 µJ and 17 µJ, respectively.

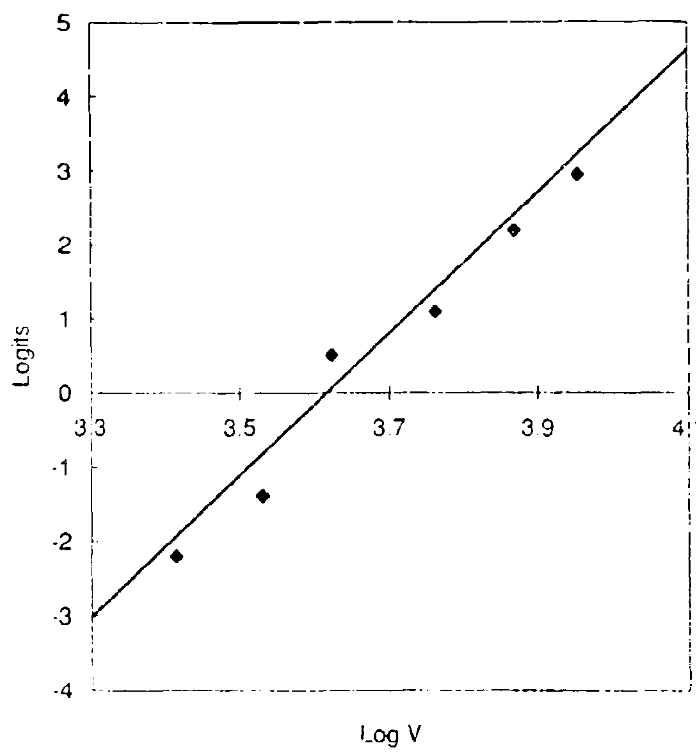


Figure 11: Plot of log voltages against empirical logits. The straight line is the logit regression line.

3.2.4 *Chi-squared Test*

Chi-squared analyses were conducted on the probit and logit results. For the probit analysis a chi-squared value of $x^2 = 3.948$ was found. This value is exceeded in 41% of cases.

A probit line which gives a chi-squared value corresponding to a percentage less than 5% is considered a poor fit and is not the true relationship between percentage fired and (logarithmic) voltage [5]. We conclude that the probit line relating the logarithms of the voltages to the empirical probits is a good fit. Similarly, an analysis was conducted of the logit results. The chi-squared value was $x^2 = 3.62$ which is exceeded in 46% of cases. This high percentage indicates that the logit line is also a good fit to the observed firing data.

3.3 *Comparison of Test Methods*

In the probit analysis of section 3.2.1 it was assumed that the logarithms of the voltage sensitivities were normally distributed. This was also assumed for the Bruceton analysis. The Bruceton method was useful for obtaining rough estimates of the 50% fire level and the level spacing. These initial estimates were used as a basis for the rundown procedure.

There is no reason for favouring the results of either the logit or the probit tests on the basis of the chi-squared analyses. There is obviously a discrepancy between the two methods with respect to the determined 0.1% function levels and no-fire thresholds. This discrepancy is unavoidable because, although both the probit and logit methods provide a good fit to the observed data, the threshold voltage values are obtained by extrapolation. This extrapolation creates uncertainty in the 0.1% FL and NFT determinations.

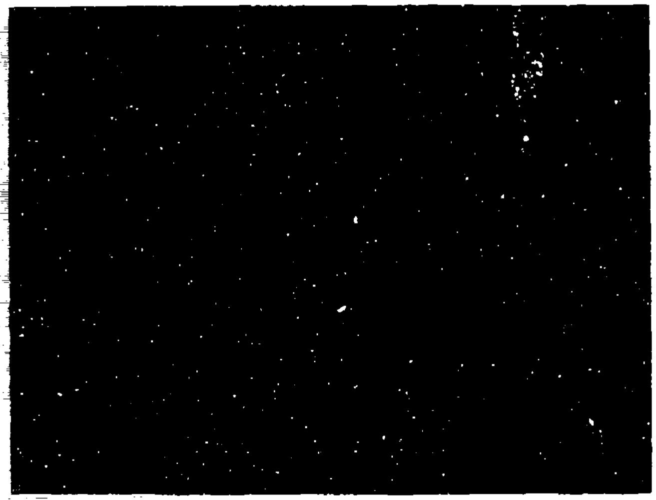
3.4 *Comparison with DC Firing Levels*

In sections 3.2.1 and 3.2.3 the NFT energy (0.1% FL, 95% confidence interval) was estimated as 48 µJ and 17 µJ, respectively. The NFT for DC initiation (0.1% FL, 95% confidence interval) is quoted in [11] as 2.2 µJ and in [12] as 5 µJ.

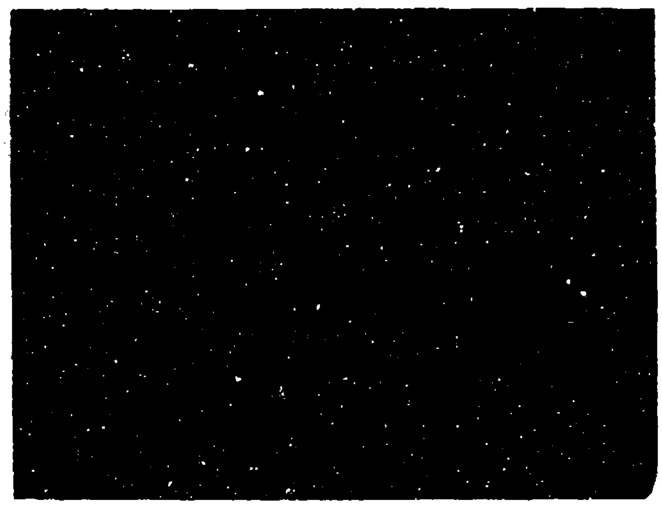
However, it must be remembered that no account has been taken of the effects of the series resistance of the discharge network. Some of the available energy of the storage capacitor will be dissipated by this resistance, reducing the energy discharged into the primer. The magnitude of this lost energy is a function of the primer resistance and this is expected to vary after discharge commences and prior to initiation. Some of the available energy is also dissipated in the spark resistance.

3.5 *Analysis of CRO Traces*

Representative photographs of the CRO traces may be found in Figure 12. From analysis of the CRO traces it was found that the pulse width was less than about 0.1 ms which is less than 0.1 times the thermal time constant of the M52A3B1 primer (160 µs [11]). This means we are justified in using the energy (rather then the power) to characterise these primers. (The thermal time constant characterises the temperature rise of the EED on application of an electrical stimulus).



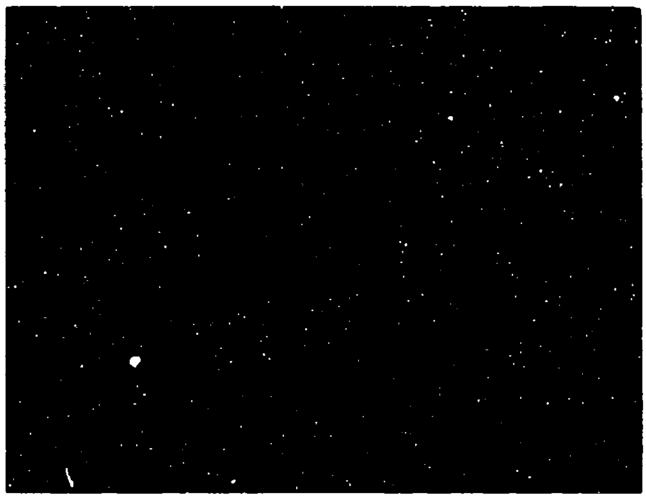
(a)



(b)

Figure 12: Representative photographs of CRO traces. The resistances are the primer resistances measured before insertion of the cartridge case in the breech block. The voltages are the test voltages. (a) Resistance = 20.4 kΩ. Voltage = 1 kV. (b) Resistance = 22.3 kΩ. Voltage = 2.6 kV. (c) Resistance = 27.5 kΩ. Voltage = 3.4 kV. (d) Resistance = 6.5 kΩ. Voltage = 4.2 kV. (e) Resistance = 57.5 kΩ. Voltage = 5.8 kV. (f) Resistance = 30.8 kΩ. Voltage = 7.4 kV. (g) Resistance = 23.2 kΩ. Voltage = 9 kV. (h) Resistance = 15.4 kΩ. Voltage = 10.6 kV.

(c)



(d)

Figure 12 (Contd): *Representative photographs of CRO traces. The resistances are the primer resistances measured before insertion of the cartridge case in the breech block. The voltages are the test voltages. (a) Resistance = 20.4 kΩ. Voltage = 1 kV.*
(b) Resistance = 22.3 kΩ. Voltage = 2.6 kV. (c) Resistance = 27.5 kΩ.
Voltage = 3.4 kV. (d) Resistance = 6.5 kΩ. Voltage = 4.2 kV.
(e) Resistance = 57.5 kΩ. Voltage = 5.8 kV. (f) Resistance = 30.8 kΩ.
Voltage = 7.4 kV. (g) Resistance = 23.2 kΩ. Voltage = 9 kV.
(h) Resistance = 15.4 kΩ. Voltage = 10.6 kV.

(e)

(f)

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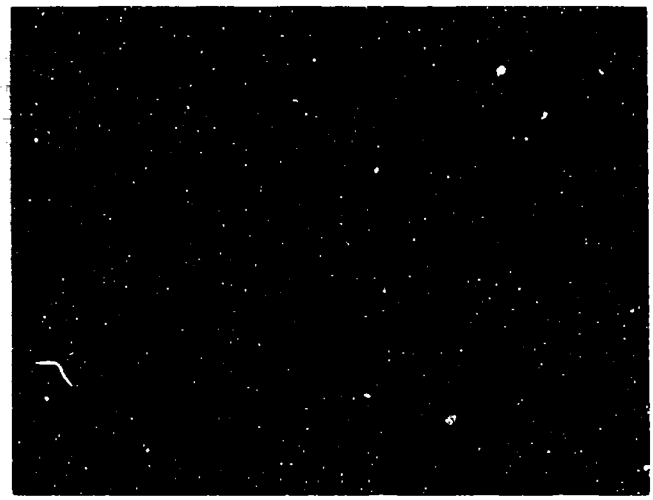
(g)



(h)

Figure 12 (Contd): Representative photographs of CRO traces. The resistances are the primer resistances measured before insertion of the cartridge case in the breech block. The voltages are the test voltages. (a) Resistance = 20.4 kΩ. Voltage = 1 kV. (b) Resistance = 22.3 kΩ. Voltage = 2.6 kV. (c) Resistance = 27.5 kΩ. Voltage = 3.4 kV. (d) Resistance = 6.5 kΩ. Voltage = 4.2 kV. (e) Resistance = 57.5 kΩ. Voltage = 5.8 kV. (f) Resistance = 30.8 kΩ. Voltage = 7.4 kV. (g) Resistance = 23.2 kΩ. Voltage = 9 kV. (h) Resistance = 15.4 kΩ. Voltage = 10.6 kV.

4. Conclusions and Recommendations

We have successfully concluded a series of firings and analyses to determine the electrostatic discharge characteristics of the M52A3B1 primer. The Bruceton, probit, logit and AMCR methods have been used to analyse the data. The probit and logit analyses yielded the most realistic results and the results of those analyses will be quoted here. The emphasis has been on safety. The probit analysis predicts that the voltage 0.1% function level estimate and no-fire threshold (using a single-sided 95% confidence interval) are 1142 V and 799 V respectively. The corresponding values for the logit analysis are 781 V and 477 V. The 0.1% FL and NFT energy were estimated as 98 μJ and 48 μJ by probit analysis. The corresponding values for the logit analysis are 46 μJ and 17 μJ. By comparison the NFT for DC initiation has been quoted as 2.2 μJ or 5 μJ.

We have, however, taken no account of the series resistance of the discharge network in determining the energy input to the primer. Taking this into account would reduce the obtained NFT values. It would be useful if the voltage across the primer could be measured directly as a function of time. Even without a precise knowledge of the energy input to the primer, the results obtained in this work are useful in determining the hazard level of the M52A3B1 primer (in terms of discharge voltage). This is because the data in this report have been obtained from a simulator which replicates actual human discharge. Further, this discharge has been designed to reproduce what is considered a worst-case scenario involving discharge from a hand-held metal object.

It would also be useful if future work could be conducted to elucidate the effects of factors such as temperature, humidity and barometric pressure on the discharge.

Another important factor is the approach speed of the electrode bearing the electrostatic charge. It has been shown [13] that a correlation exists between electrode approach speed and the rising slope of the discharge pulse. This phenomenon requires further investigation in the context of this work. It is relevant because, in practice, there will be a variation in the approach speed of e.g. a person's hand to the ordnance under ESD threat.

The different values obtained for the 0.1% FL and NFT when they are calculated by different methods is also a problem that requires further investigation.

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Table 1: Results of Bruceton firings for M52A3B1 primers

Temperature: 33°C. Relative Humidity: 37%

Shot No	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Test Voltage (kV)	Result
1	16.84		5	NF
2	57.7	67.0	7	NF
3	21.1	21.6	9	F
4	29.6	28.4	7	F
5	16.2	16.1	5	NF
6	77.2	77.3	7	F
7	11.3	11.3	5	F
8	20.1	20.5	3	NF
9	2.1	2.3	5	F
10	34.9	33.7	3	NF
11	41.5	27.7	5	F
12	42.5	41.0	3	F
13	4.8	4.8	1	NF
14	18.0	17.8	3	NF
15	49.6	46.5	5	F
16	28.7	28.5	3	F
17	10.3	10.1	1	NF
18	23.1	23.5	3	NF
19	33.1	32.7	5	F
20	20.0	30.1	3	NF

Table 2: Rundown test V=1.0 kV

First 2 shots: Temperature: 32.5°C, Relative humidity: 52%.
Other shots: Temperature: 29°C, Relative humidity: 32%.

Shot No	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	16.1	15.9	NF
2	19.4	19.3	NF
3	14.1	13.2	NF
4	14.6	14.3	NF
5	35.3	35.2	NF
6	13.2	13.2	NF
7	13.1	12.8	NF
8	20.4	17.6	NF
9	10.5	10.4	NF
10	53.9	33.8	NF
11	11.8	8.7	NF
12	8.3	7.2	NF
13	13.2	5.3	NF
14	10.1	9.6	NF
15	8.8	7.7	NF
16	6.9	6.6	NF
17	23.6	21.7	NF
18	16.3	11.8	NF
19	24.9	25.0	NF
20	24.0	15.0	NF

Table 3: Rundown test V = 2.6 kV

Temperature: 32.5 °C. Relative humidity: 52%.

Shot No.	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	10.8	11.0	F
2	83.5	73.9	NF
3	17.6	12.3	F
4	11.3	7.8	NF
5	24.7	23.5	NF
6	39.9	39.9	NF
7	5.8	5.8	NF
8	13.7	14.3	NF
9	42.6	47.7	NF
10	8.4	7.9	NF
11	6.7	5.2	NF
12	18.7	20.1	NF
13	31.2	27.3	NF
14	30.0	26.9	NF
15	22.3	22.2	NF
16	54.9	53.5	NF
17	27.4	29.6	NF
18	10.3	10.6	NF
19	19.0	20.5	NF
20	58.0	56.5	NF

Table 4: Rundown test V = 3.4 kV

Temperature: 36°C, Relative humidity: 29%.

Shot No.	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	33.0	32.9	NF
2	268.8	214	NF
3	52.3	46.1	NF
4	9.2	7.9	NF
5	209.5	151.2	F
6	35.3	35.3	NF
7	15.0	14.7	NF
8	9.3	9.0	F
9	162.8	117.8	NF
10	12.6	12.5	NF
11	19.2	18.9	NF
12	13.2	12.6	F
13	17.7	23.9	NF
14	27.5	27.2	NF
15	18.3	17.9	NF
16	22.4	22.1	NF
17	21.0	20.1	F
18	5.9	5.7	NF
19	7.4	7.2	NF
20	13.9	13.8	NF

Table 5: Rundown test V = 4.2 kV (initial 20 shots)

Temperature: 29°C, Relative humidity: 40%.

Shot No.	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	31.7	31.4	NF
2	6.5	6.4	F
3	13.3	13.3	F
4	21.9	21.9	NF
5	130.3	130.3	F
6	28.5	3.5	F
7	36.8	4.0	F
8	38.4	1.7	F
9	6.2	2.0	NF
10	8.8	4.4	NF
11	28.6	1.8	F
12	12.5	6.7	F
13	53.4	8.0	F
14	14.7	14.7	F
15	15.4	12.5	F
16	10.4	3.5	F
17	18.2	3.7	F
18	17.9	7.8	F
19	14.6	3.1	NF
20	14.8	14.8	F

Table 6: Rundown test V = 4.2 kV (second lot of 20 shots)

Temperature: 32°C, Relative humidity: 44%

Shot No.	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	5.4	5.2	F
2	15.1	15.1	NF
3	5.0	5.0	NF
4	19.4	19.4	F
5	15.7	15.4	F
6	7.4	7.2	F
7	19.2	18.9	F
8	15.3	15.3	NF
9	257.0	264.0	F
10	9.6	7.9	F
11	20.0	20.0	NF
12	12.3	12.4	NF
13	162.5	163.1	F
14	24.9	24.9	NF
15	61.5	61.5	NF
16	10.4	10.4	NF
17	117.0	117.8	F
18	9.6	9.7	NF
19	40.2	40.1	F
20	15.0	13.2	NF

Table 7: Rundown test V = 5.8 kV

Temperature: 29°C, Relative humidity: 40%

Shot No	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	14.6	14.4	F
2	10.3	10.2	F
3	11.8	11.7	F
4	10.6	0.0	NF
5	8.4	8.5	NF
6	4.3	3.0	F
7	16.9	0.0	F
8	10.0	0.0	F
9	266.0	263.0	NF
10	19.9	1.0	F
11	20.6	20.9	F
12	13.2	13.0	F
13	17.5	4.5	F
14	3.6	5.0	F
15	57.5	3.0	F
16	21.1	0.0	F
17	16.5	3.7	F
18	22.3	1.4	F
19	12.4	0.0	NF
20	18.0	1.5	NF

Table 8: Rundown test V = 7.4 kV

For the first 8 shots: Temperature: 29°C, Relative humidity: 40%
For the other shots: Temperature: 33°C, Relative humidity: 30%

Shot No	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	54.8	0.0	F
2	10.9	2.2	F
3	18.1	17.8	F
4	166.0	165.4	F
5	7.3	7.0	F
6	15.6	11.6	NF
7	30.8	2.1	F
8	44.9	45.3	F
9	9.8	7.4	F
10	8.7	8.7	NF
11	31.5	31.2	F
12	9.6	9.5	F
13	12.0	10.9	F
14	18.9	19.4	F
15	43.8	43.5	F
16	6.5	6.4	F
17	2.7	2.6	F
18	3.2	3.3	F
19	13.2	13.3	F
20	19.2	19.5	F

Table 9: *Rundown test V = 9.0 kV*

Temperature: 33°C, Relative humidity: 30%

Shot No.	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	17.3	16.7	NF
2	17.6	16.6	F
3	9.9	10.2	F
4	49.3	47.8	F
5	35.6	35.9	F
6	7.2	7.2	F
7	85.0	84.5	F
8	17.2	17.2	F
9	23.6	22.9	F
10	6.6	6.7	F
11	12.6	12.6	F
12	23.2	23.4	F
13	12.3	12.2	F
14	23.2	22.5	F
15	23.6	23.5	F
16	8.4	8.3	F
17	15.6	17.7	F
18	44.7	41.3	F
19	27.3	27.1	F
20	18.1	14.6	F

Table 10: *Rundown test V = 10.0 kV*

Temperature: 33°C, Relative humidity: 30%

Shot No	Primer Resistance (kΩ)	Rig Resistance (kΩ) *	Result
1	52.7	52.6	F
2	8.2	8.2	F
3	6.4	6.3	F
4	144.0	200.0	F
5	12.3	13.1	F
6	18.0	18.3	F
7	30.0	30.1	F
8	65.0	64.7	F
9	11.9	11.9	F
10	26.1	25.8	F
11	9.1	9.2	F
12	18.4	19.7	F
13	166.0	166.7	F
14	15.4	15.4	F
15	13.7	13.8	F
16	10.3	10.6	F
17	11.8	12.1	F
18	24.4	21.8	F
19	29.7	30.5	F
20	7.2	7.2	F

* The rig resistance was measured after the cartridge case was inserted into the breech block. See section 2.3 for details

Table 11: Probit analysis results assuming the voltage sensitivity is log-normally distributed

Logarithmic Voltage Mean	3.620
Logarithmic Voltage Standard Deviation	0.182
Voltage 0.1% Function Level Estimate	1142 V
Voltage No-Fire Threshold Estimate (0.1%, 95% Confidence)	799 V

Table 12: Logit analysis results assuming the voltage sensitivity is log-logistically distributed

Logarithmic Voltage Mean	3.616
Logarithmic Voltage Standard Deviation	0.190
Voltage 0.1% Function Level Estimate	781 V
Voltage No-Fire Threshold Estimate (0.1%, 95% Confidence)	[illegible]77 V

SECURITY CLASSIFICATION OF THIS PAGE **UNCLASSIFIED**

REPORT NO.	AR NO.	REPORT SECURITY CLASSIFICATION
DSTO-TR-0029	AR-008-567	Unclassified

TITLE

Electrostatic testing of M52A3B1 primers

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REPORT DATE	TASK NO.	SPONSOR
June 1994	DST 91/178	DSTO

FILE NO.	REFERENCES	PAGES
G6/4/8-4462	13	30

CLASSIFICATION/LIMITATION REVIEW DATE

CLASSIFICATION/RELEASE AUTHORITY
Chief, Explosives Ordnance Division

SECONDARY DISTRIBUTION

Approved for public release

ANNOUNCEMENT

Announcement of this report is unlimited

KEYWORDS

Electroexplosive devices
Primers
Electrostatic initiation
Conducting compositions

ABSTRACT

Electrostatic sensitivity tests were conducted on M52A3B1 primers using an electrostatic discharge (ESD) gun to simulate human static discharge. The data were analysed by the Bruceton, probit, logit and AMCR techniques. The no-fire threshold (NFT) for electrostatic discharge was determined.

Electrostatic Testing of M52A3B1 Primers

H.H. Billon and L. Redman

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